

KDY 9465  
PATENT

CLAIMS:

What is claimed is:

1. A pneumatically-powered mine door installation comprising:  
a mine door frame installed in a mine passageway;  
at least one door leaf mounted on the mine door frame for swinging movement  
between open and closed positions for opening and closing the door installation, said door  
5 leaf having a first face that is subject to relatively higher air pressure and a second face that  
is subject to relatively lower air pressure when the door installation is closed;  
an extensible and retractable pneumatically-powered actuator mounted with a first  
end connected to the at least one door leaf and a second end connected to a pneumatic  
actuator anchor so that extension and retraction of the actuator causes the door leaf to  
10 swing back and forth between its open and closed positions; and  
a hydraulic checking system for controlling the speed of the at least one door leaf as  
it moves back and forth between its open and closed positions.

2. The door installation of claim 1 wherein said hydraulic checking system  
comprises:  
a housing containing hydraulic fluid;  
a piston in the housing separating the interior of the housing into a blind end fluid  
5 chamber containing a first volume of hydraulic fluid and a rod end fluid chamber  
containing a second volume of hydraulic fluid;  
a rod extending through an opening in the housing wherein one end of the rod is  
connected to the piston in the housing and the other end of the rod is exterior of the  
housing,  
10 a hydraulic circuit providing fluid connection between the first and second fluid  
chambers, said hydraulic circuit having one or more fluid flow restrictions for providing  
resistance to flow of hydraulic fluid through the hydraulic circuit; and

the piston and rod being slidable along a sliding axis of the housing to allow extension and retraction of the rod with respect to the housing, said extension or retraction of the rod requiring hydraulic fluid to flow through said one or more fluid flow restrictions.

3. The door installation of claim 2 wherein at least one fluid flow restriction comprises an adjustable needle valve.

4. The door installation of claim 2 wherein said one or more fluid flow restrictions comprise a first adjustable fluid flow restriction for adjusting the opening speed of the door leaf and a second adjustable fluid flow restriction for adjusting the closing speed of the door leaf.

5. The door installation of claim 4 wherein the first and second adjustable fluid flow restrictions comprise adjustable needle valves.

6. The door installation of claim 2 wherein said hydraulic checking system further comprises a pressurized hydraulic fluid reservoir for storing a surplus of hydraulic fluid, the pressurized fluid reservoir being in fluid connection with the hydraulic circuit, said pressurized hydraulic fluid reservoir being operable to prevent pressure in the housing from dropping below ambient air pressure when the rod retracts with respect to the housing.

7. The door installation of claim 6 wherein compressed air is used to pressurize the pressurized hydraulic fluid reservoir.

8. The door installation of claim 6 wherein said pressurized hydraulic fluid reservoir is also operable to receive a volume of hydraulic fluid displaced from the housing when the rod retracts and to supply a volume of hydraulic corresponding to the displacement of the rod to the housing when the rod extends.

9. The door installation of claim 2 wherein the rod is connected to either the at least one door leaf or a hydraulic checking system anchor and the housing is connected to the other of the door leaf or the hydraulic checking system anchor so swinging movement of the door leaf back and forth between its open and closed positions requires extension and retraction of the rod with respect to the housing.

10. The door installation of claim 9 wherein the stroke of the rod as the at least one door leaf moves from its closed to its open position is less than the stroke of the pneumatic actuator as the at least one door leaf moves from its closed position to its open position.

11. The door installation of claim 9 wherein the pressure on the first face of the door leaf and the pressure on the second face of the door leaf substantially equalize when the door leaf is at an intermediate point on the path from its closed position to its open position, and wherein the locations for the hydraulic checking system anchor and connection of the hydraulic cylinder to the door leaf are such that the ratio of the angular velocity of the door leaf to the rate at which the rod moves with respect to the hydraulic housing is substantially minimized as the door leaf reaches said intermediate point.

12. The door installation of claim 11 wherein the hydraulic checking system is anchored to a bracket welded to the pneumatic actuator.

13. The door installation of claim 9 wherein the location of the hydraulic checking anchor is selected so the ratio of the angular velocity of the door leaf to the rate at which the rod moves with respect to the hydraulic housing generally decreases as the door leaf moves along a substantial portion of the path from its closed position to its open position.

14. The door installation of claim 9 wherein the location of the hydraulic checking system anchor is selected so the line of action of the hydraulic checking system is

substantially parallel to the at least one door leaf when the door leaf is in its closed position.

15. The door installation of claim 9 wherein the hydraulic checking system anchor comprises a bracket welded to a column of the door frame.

16. The door installation of claim 9 wherein the locations for the hydraulic checking system anchor and connection of the rod to the door leaf are selected so the sliding axis of the hydraulic system is substantially perpendicular to the door leaf when the at least one door leaf has been moved between 0 and 10 degrees from its closed position to its open position.

17. The door installation of claim 1 wherein the pneumatic actuator is mounted so its leverage in opening the at least one door leaf is substantially at its maximum when the at least one door leaf is in its closed position.

18. The door installation of claim 1 wherein the pneumatic actuator is mounted so the ratio of the angular velocity of the at least one door leaf to the rate at which the rod of the pneumatic actuator moves with respect to the pneumatic housing generally increases as the door leaf moves along a substantial portion of the path from its closed position to its open position.

19. The door installation of claim 1 wherein the door leaf opens by swinging toward the high pressure side of the door leaf.

20. A pneumatically-powered mine door installation for operation in a mine with an air ventilation system, said door installation comprising:

a mine door frame installed in a mine passageway;

first and second door leafs mounted on opposite sides of the mine door frame for swinging movement between open and closed positions, each door leaf having a first face

that is subject to relatively higher air pressure and a second face that is subject to relatively lower air pressure when the first and second door leafs are in their closed positions;

for each of the first and second door leafs an extensible and retractable pneumatically-powered actuator mounted with a first end connected to the respective door leaf and a second end connected to a pneumatic actuator anchor so that extension and retraction of the actuator causes the respective door leaf to swing back and forth between its open and closed positions; and

a hydraulic checking system for controlling the speed of the first and second door leafs as they swing back and forth between their open and closed positions.

21. The door installation of claim 20 wherein said hydraulic checking system comprises:

first and second housings containing hydraulic fluid;

a first piston within the first housing and a second piston within the second housing, each of the first and second pistons separating the interior of a respective housing into a first fluid chamber containing a first volume of hydraulic fluid and a second fluid chamber containing a second volume of hydraulic fluid;

a hydraulic circuit providing fluid connection between the first and second fluid chambers of each housing, said hydraulic circuit having one or more fluid flow restrictions for providing resistance to flow of hydraulic fluid through the hydraulic circuit; and

a first rod extending through an opening in the first housing having one end connected to the first piston and the other end on the exterior of the first housing and a second rod extending through an opening in the second housing having one end connected to the second piston and the other end on the exterior of the second housing,

each piston and rod being slidable along a sliding axis of a respective housing to allow extension and retraction of the rod with respect to the housing, said extension and retraction of either rod requiring hydraulic fluid to flow through the one or more fluid flow restrictions, each rod being connected to either the respective door leaf or a hydraulic checking system anchor and each housing being connected to the other of the respective door leaf or the hydraulic checking system anchor so that swinging movement of the first

and second door leafs causes the respective rod to extend or retract with respect to its housing.

22. The door installation of claim 21 wherein the one more fluid flow restrictions comprise:

5 a first adjustable fluid flow restriction capable of adjusting the amount of force countering extension of the first and second rods with respect to the first and second housings independent of the amount of force countering retraction of the first and second rods with respect to the first and second housings; and

10 a second adjustable fluid flow restriction capable of adjusting the amount of force resisting retraction of the first and second rods with respect to the first and second housings independent of the amount of force countering extension of the first and second rods with respect to the first and second housings.

23. The door installation of claim 22 wherein the first and second adjustable fluid flow restrictions comprise adjustable needle valves.

24. The door installation of claim 21 wherein the one or more fluid flow restrictions comprise:

5 a first adjustable fluid flow restriction capable of adjusting the amount of force countering extension and retraction of the first rod with respect to the first housing independent of the amount of force countering extension and retraction of second rod with respect to the second housing; and

10 and a second adjustable fluid flow restriction capable of adjusting the amount of force resisting extension and retraction of the second rod with respect to the second housing independent of the amount of force resisting extension and retraction of the first rod with respect to the first housing.

25. The door installation of claim 24 wherein the first and second adjustable fluid flow restrictions comprise adjustable needle valves.

26. The door installation of claim 24 wherein the first and second adjustable fluid flow restrictions are adjustable to establish a closing sequence for the first and second door leafs.

27. The door installation of claim 21 wherein the one or more fluid flow restrictions comprise:

a first adjustable fluid flow restriction capable of adjusting the amount of force countering extension of the first and second rods with respect to the first and second housings independent of the amount of force countering retraction of the first and second rods with respect to the first and second housings;

a second adjustable fluid flow restriction capable of adjusting the amount of force resisting retraction of the first and second rods with respect to the first and second housings independent of the amount of force countering extension of the first and second rods with respect to the first and second housings;

a third adjustable fluid flow restriction capable of adjusting the amount of force countering extension and retraction of the first rod with respect to the first housing independent of the amount of force countering extension and retraction of second rod with respect to the second housing; and

and a fourth adjustable fluid flow restriction capable of adjusting the amount of force resisting extension and retraction of the second rod with respect to the second housing independent of the amount of force resisting extension and retraction of the first rod with respect to the first housing.

28. The door installation of claim 27 wherein the adjustable fluid flow restrictions comprise adjustable needle valves.

29. The door installation of claim 27 wherein the third and fourth fluid flow restrictions are adjustable to establish a closing sequence for the first and second door leafs.

30. A control system for operating a pneumatically-powered door installation, said control system comprising:

a moveable control valve for selectively supplying air power to one or more actuators to cause swinging movement of one or more door leafs in a door installation in a mine passageway, said moveable control valve being biased toward a first position in which air power is not supplied to the one or more pneumatic actuators and moveable to a second position in which air power is supplied to the one or more pneumatic actuators;

a second valve operable to selectively open and close an air supply line between the control valve and a source of compressed air, said control valve being moved to its second position by the compressed air when the air supply line is open; and

a calibrated vent for venting the air supply line between the control valve and the second valve.

31. The control system of claim 30 wherein the calibrated vent is located closer to the control valve than the second valve.

32. The control system of claim 30 wherein the calibrated vent is adjacent the control valve.

33. The control system of claim 30 wherein the calibrated vent comprises a hole drilled through a plug screwed into one leg of a pipe tee that is inserted in the air supply line.

34. A control system for operating a pneumatically-powered mine door installation, said control system comprising:

a moveable control valve for selectively supplying air power to one or more actuators to open one or more door leafs in a door installation;

one or more operating valves operable to open and close an air supply line between the control valve and a source of compressed air, said control valve being moved when said



KDY 9465  
PATENT

air supply line is open to a position supplying air power to said one or more actuators to open the one or more door leafs; and

a limit valve which is also operable to open and close said air supply line between the control valve and the source of compressed air, said limit valve being operably linked to a second door installation whereby the air supply line is closed when the second door installation is open.

35. The control system of claim 33 wherein said one or more operating valves includes a second operating valve operable to selectively open or close a second air supply line between the control valve and the source of compressed air, said control valve being moved when said second air supply line is open to a position supplying air power to said one or more actuators to close the one or more door leafs, said second air supply line being plumbed around the limit valve.